Mercury Deposition in the Mid-Atlantic Region: Data, Models, and Limitations

Virginia Mercury Symposium

Newport News, Virginia

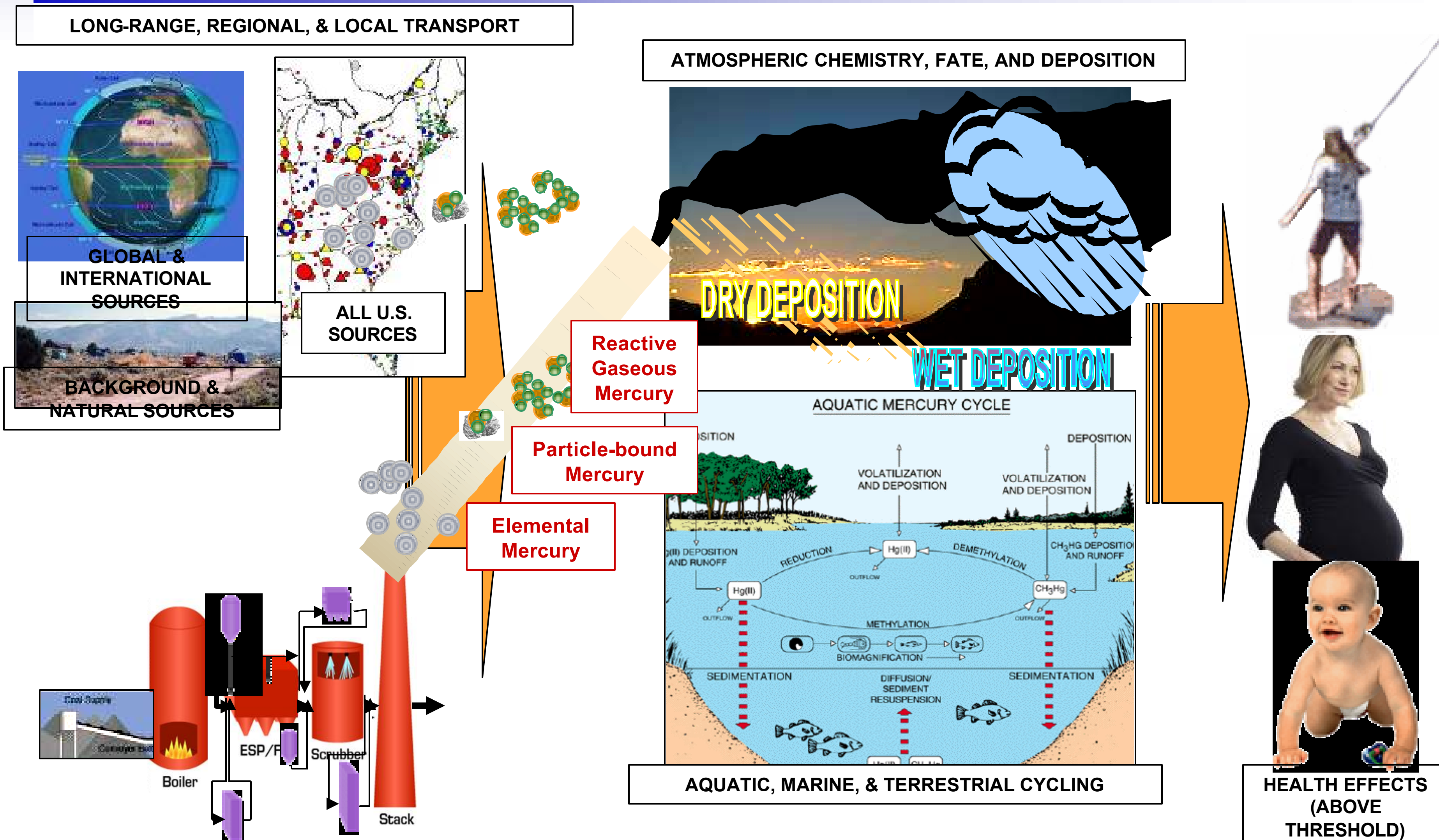
November 28, 2007

LEONARD LEVIN

Electric Power Research Institute

Palo Alto, California

Mercury from Air Sources to Receptors

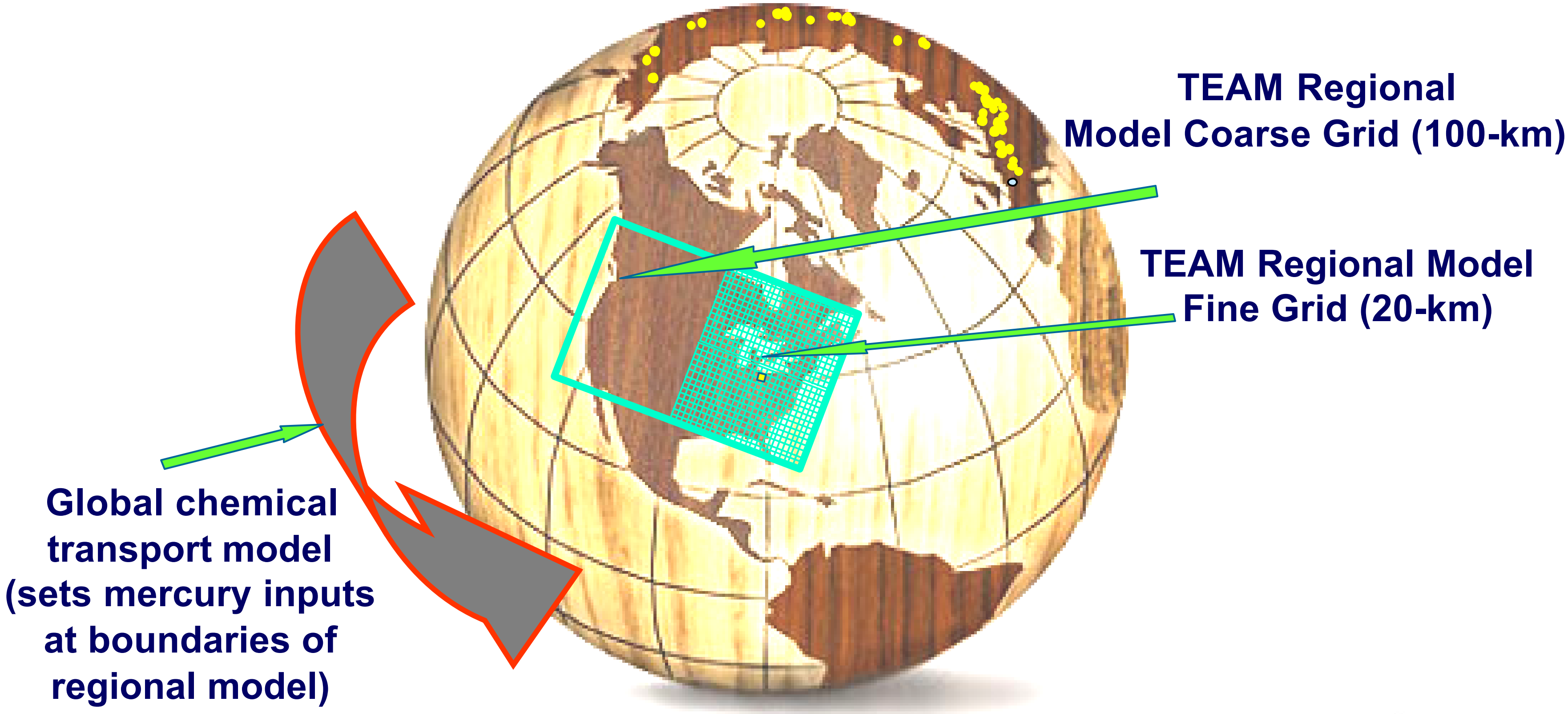


ELECTRIC POWER RESEARCH INSTITUTE

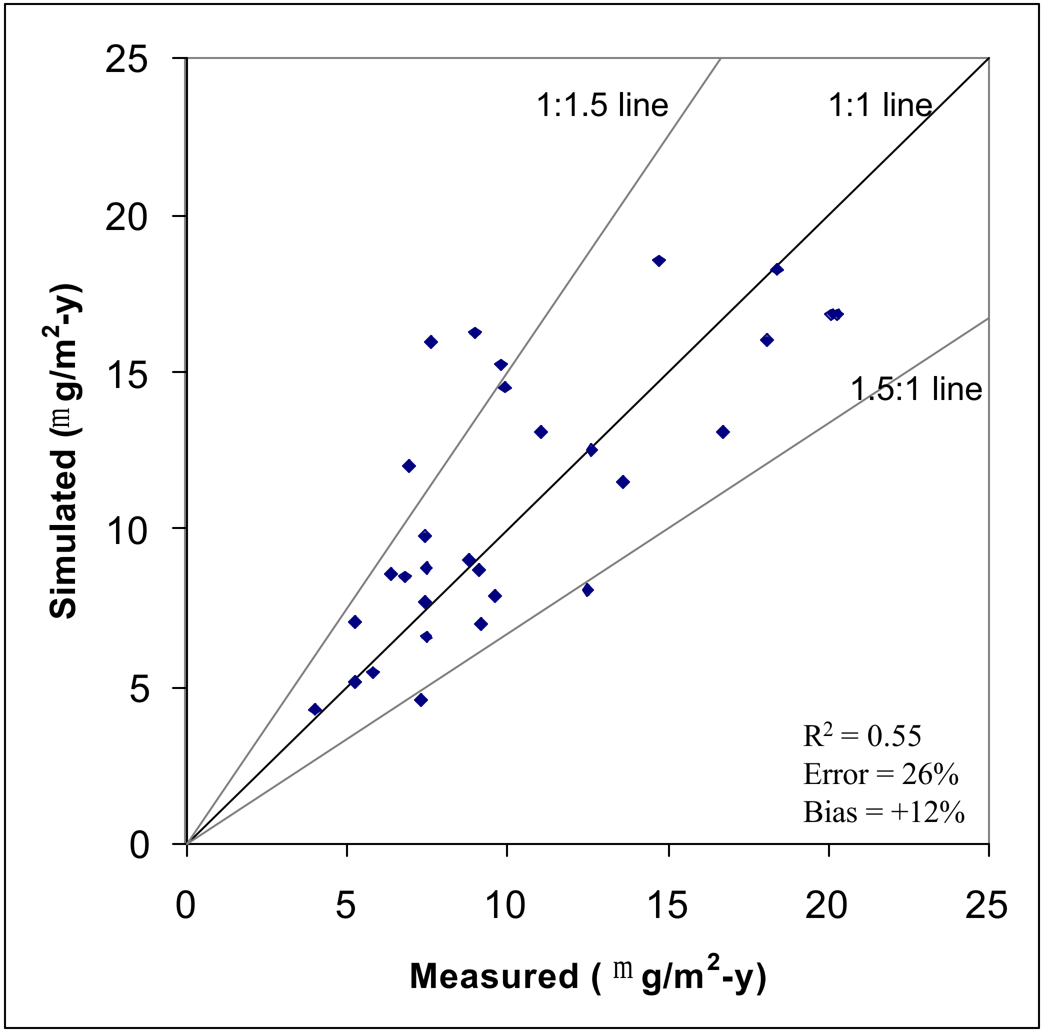
Mercury Modeling System

Model elements:

- **Primary mercury reactions – oxidation, reduction, behavior in cloudy environments**
- **Global transport**
- **Rainfall patterns**



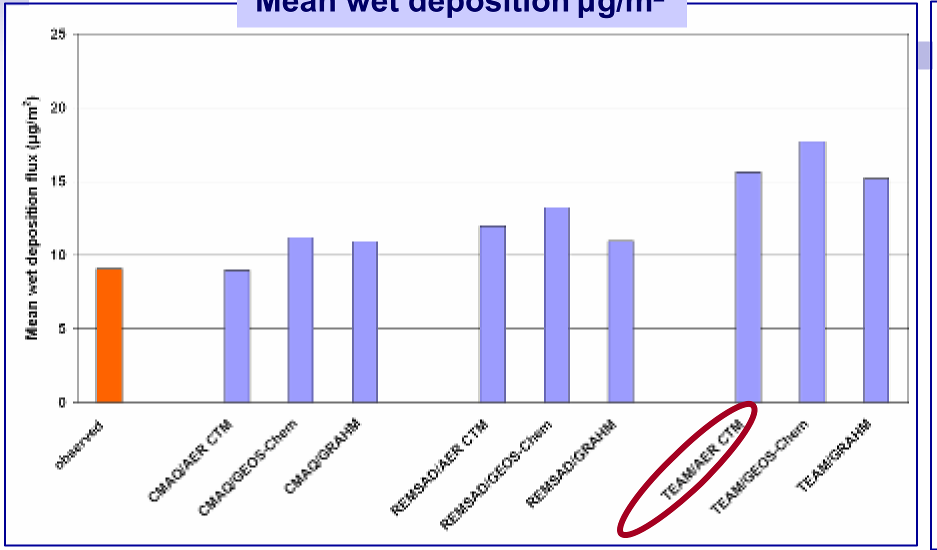
Model Test vs. Data (1998 Test)



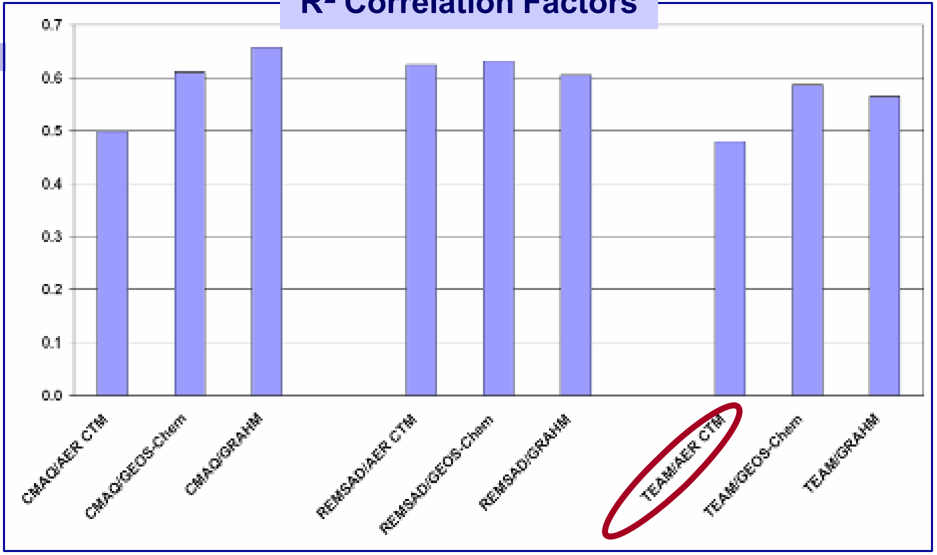
EPRI ELECTRIC POWER RESEARCH INSTITUTE

EPA PERFORMANCE TESTS: Regional Models vs. Observed Wet Deposition, 2001 Simulations

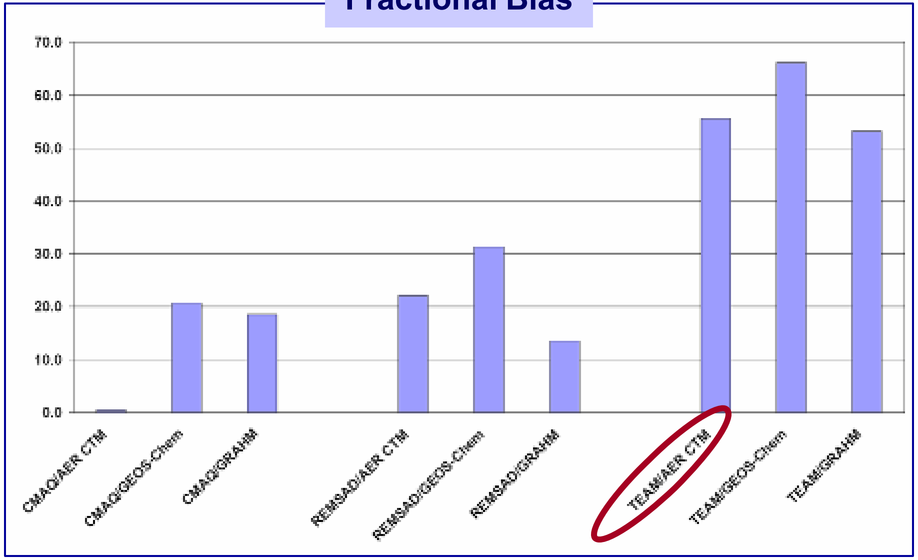
Mean wet deposition µg/m^2



R^2 Correlation Factors



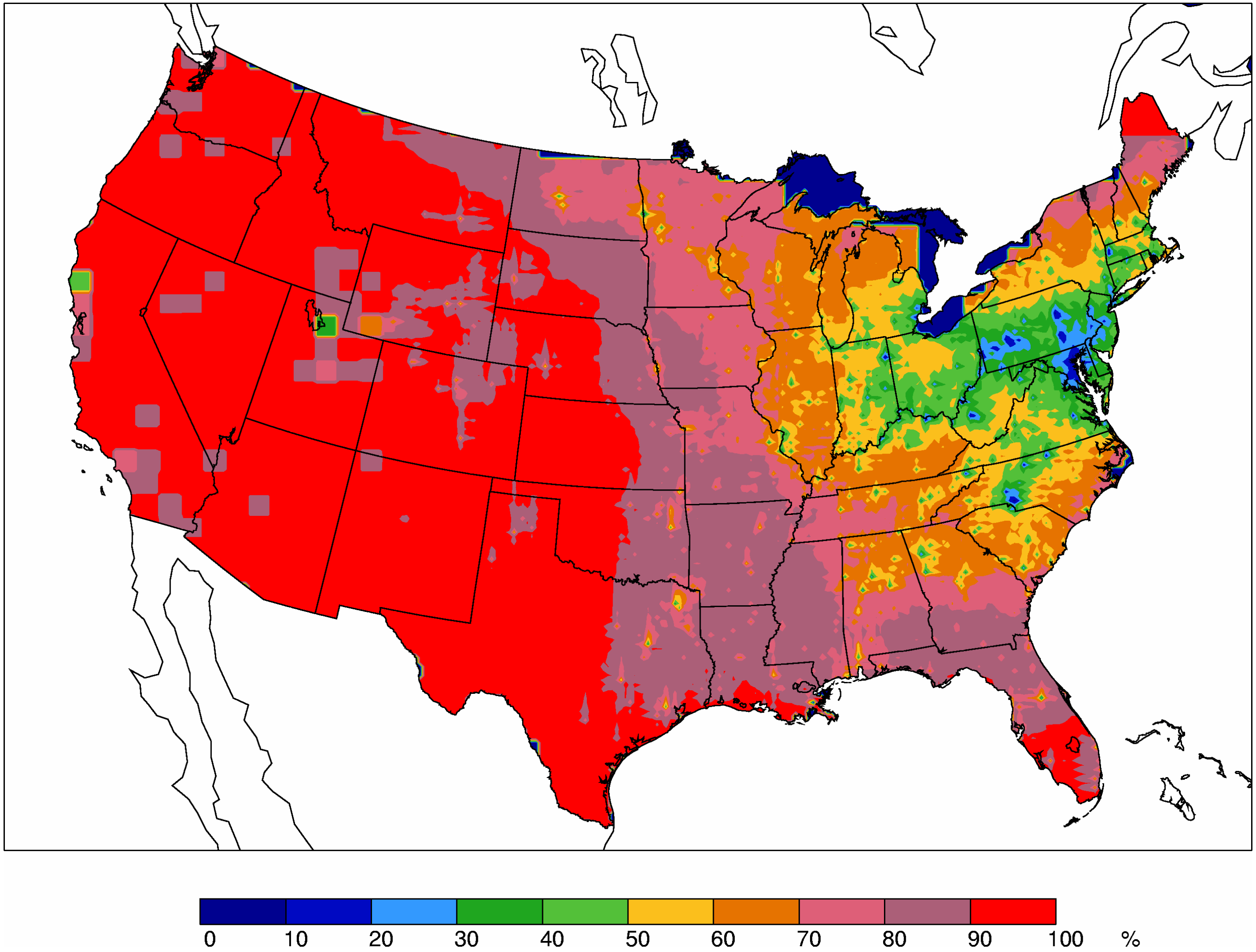
Fractional Bias



Fractional Error

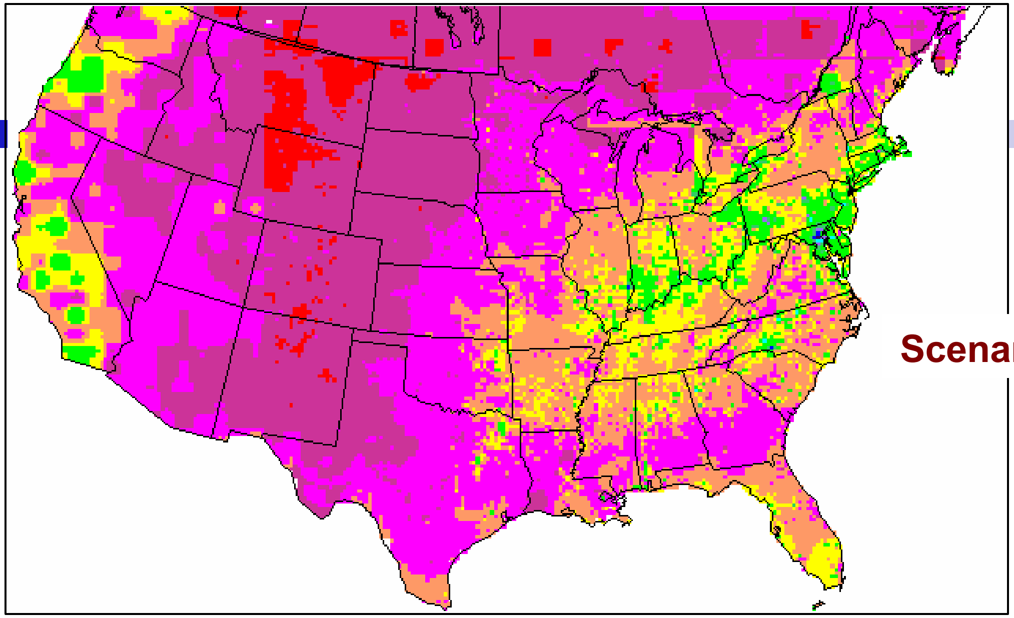
ELECTRIC POWER RESEARCH INSTITUTE

Contribution (%) of non-U.S. mercury emissions to mercury deposition



EPRI ELECTRIC POWER RESEARCH INSTITUTE

NATIONAL MERCURY DEPOSITION: 3 Scenarios

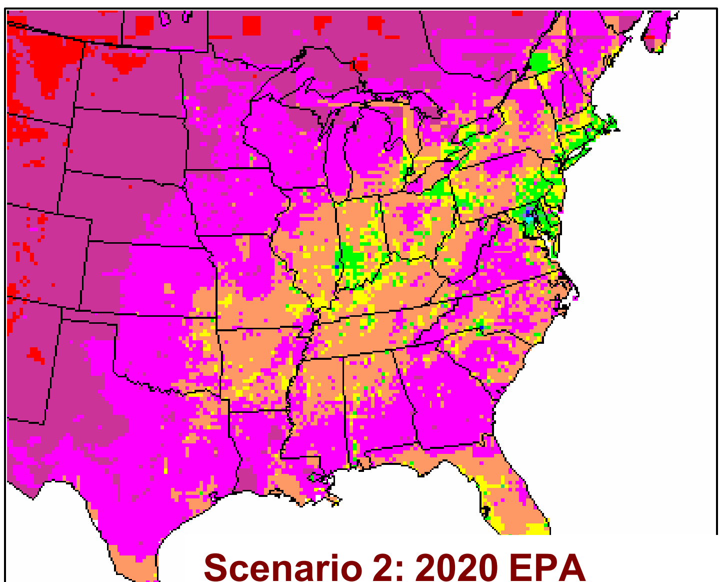


Scenario 1: 2004 Base Case

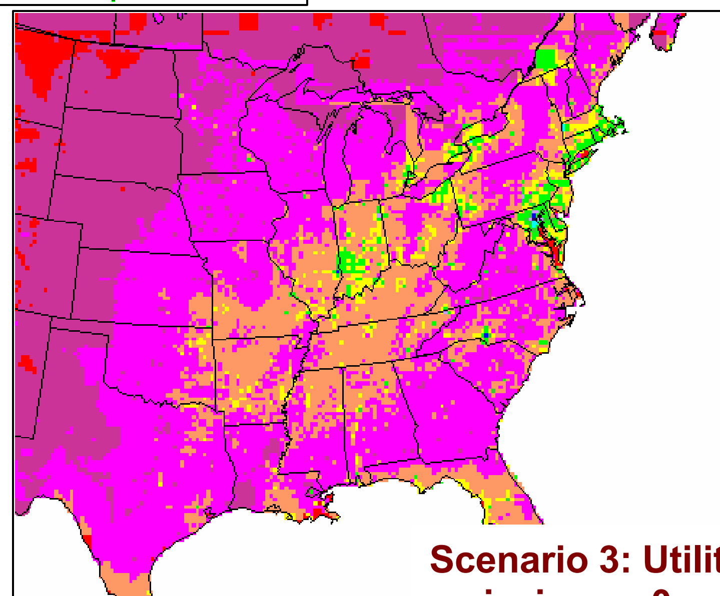
Mercury deposition ($\mu g/m^2$-yr)

- 150 - 204
- 100 - 150
- 75 - 100
- 50 - 75
- 25 - 50
- 20 - 25
- 15 - 20
- 10 - 15
- 5 - 10
- 0 - 5

1 $\mu g/m^2$-yr is about 1 ounce of mercury over 10 square miles, per year



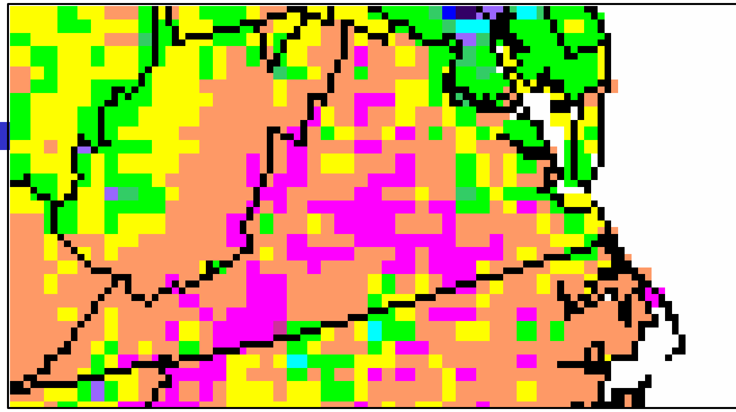
Scenario 2: 2020 EPA Regulations (CAIR + CAMR)



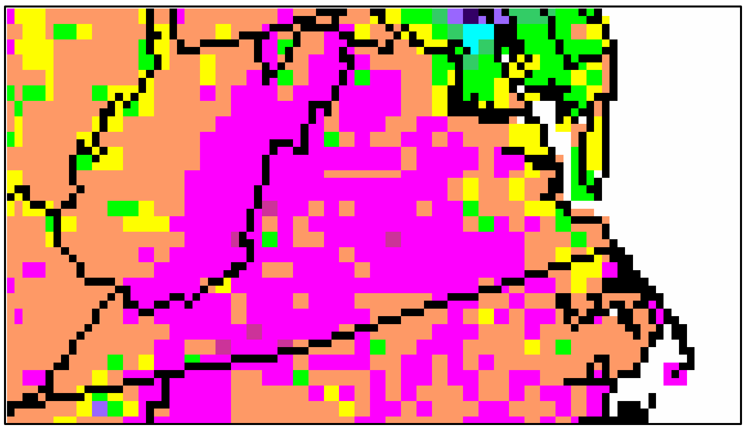
Scenario 3: Utility mercury emissions = 0

ELECTRIC POWER RESEARCH INSTITUTE

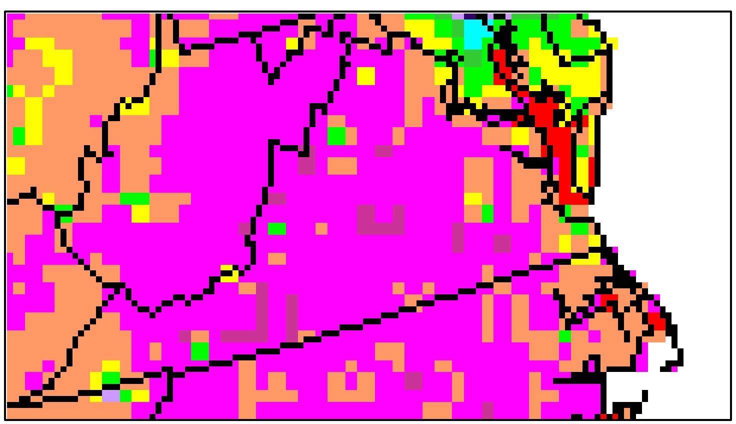
DEPOSITION IN THE MID-ATLANTIC



Scenario 1:
2004 Base Case



Scenario 2:
2020 EPA Regulations (CAIR + CAMR)



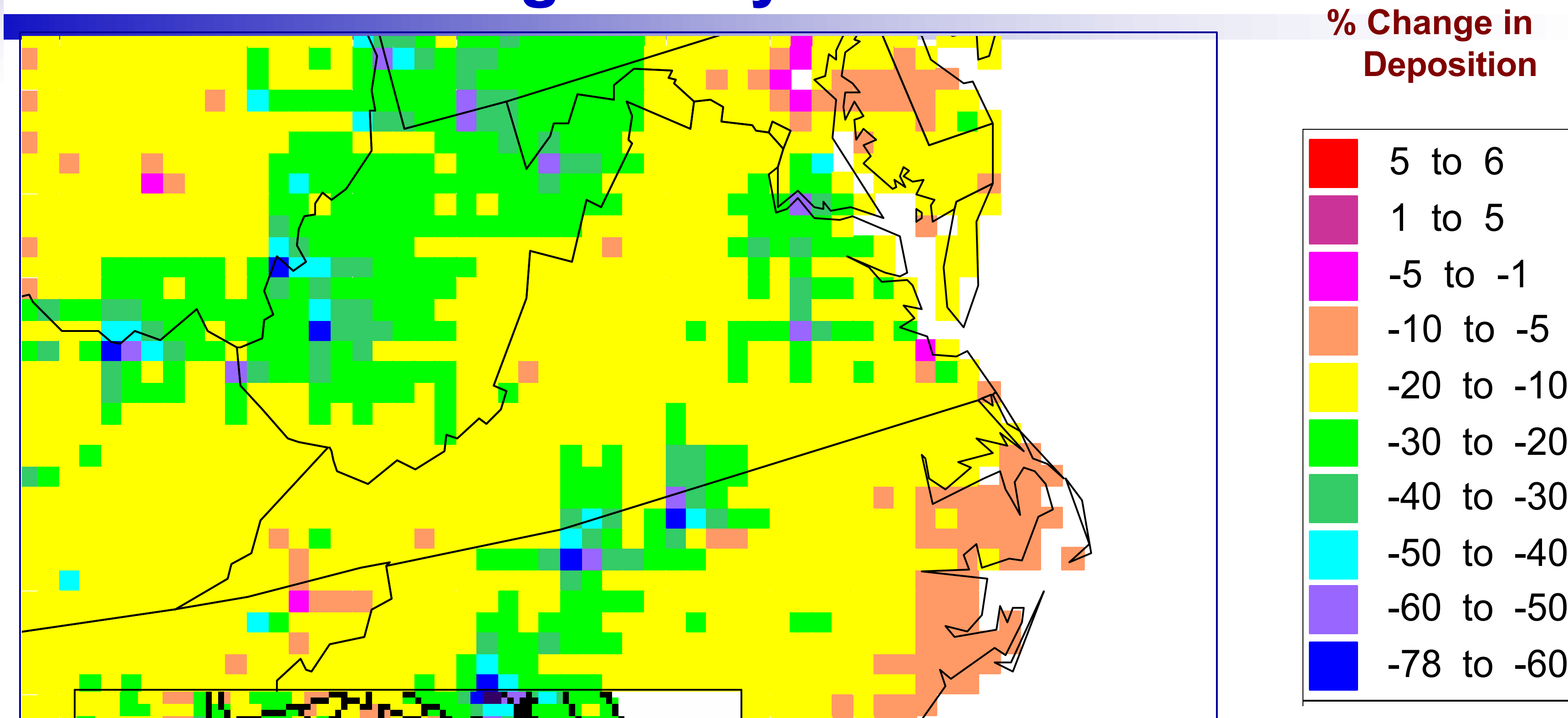
Scenario 3:
Utility mercury emissions = 0

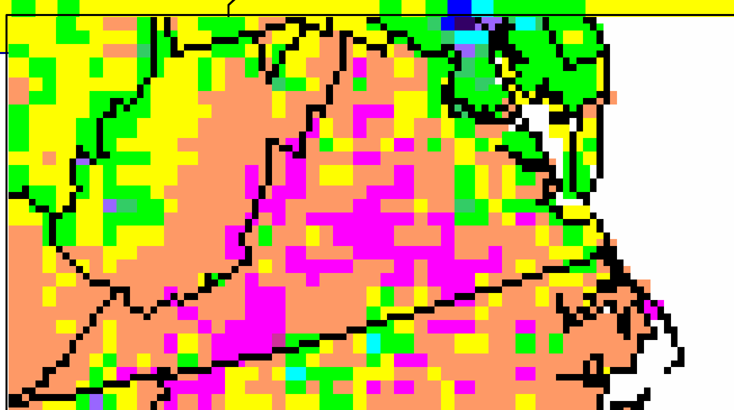
Mercury deposition ($\mu g/m^2$-yr)

- 150 - 204
- 100 - 150
- 75 - 100
- 50 - 75
- 25 - 50
- 20 - 25
- 15 - 20
- 10 - 15
- 5 - 10
- 0 - 5

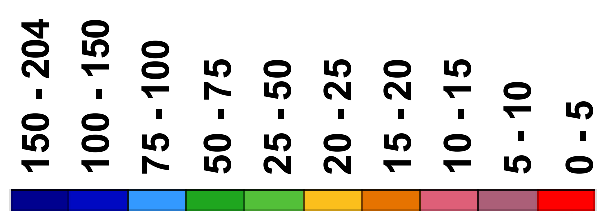
EPRI ELECTRIC POWER RESEARCH INSTITUTE

Percent Change in Total Deposition, 2004 to 2020 EPA Regulatory Scenario





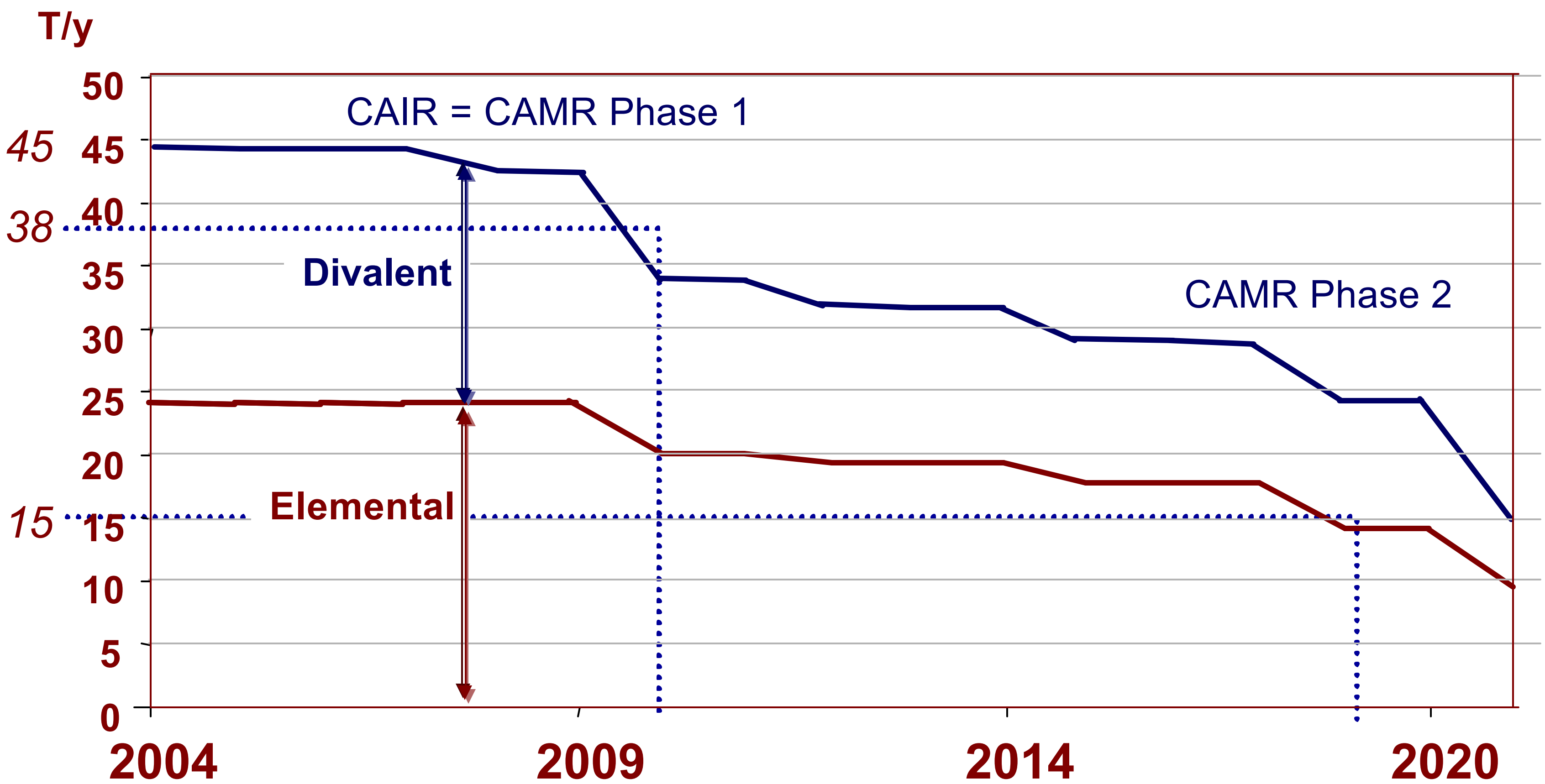
2004 mercury deposition ($\mu g/m^2$-yr)



Some Caveats

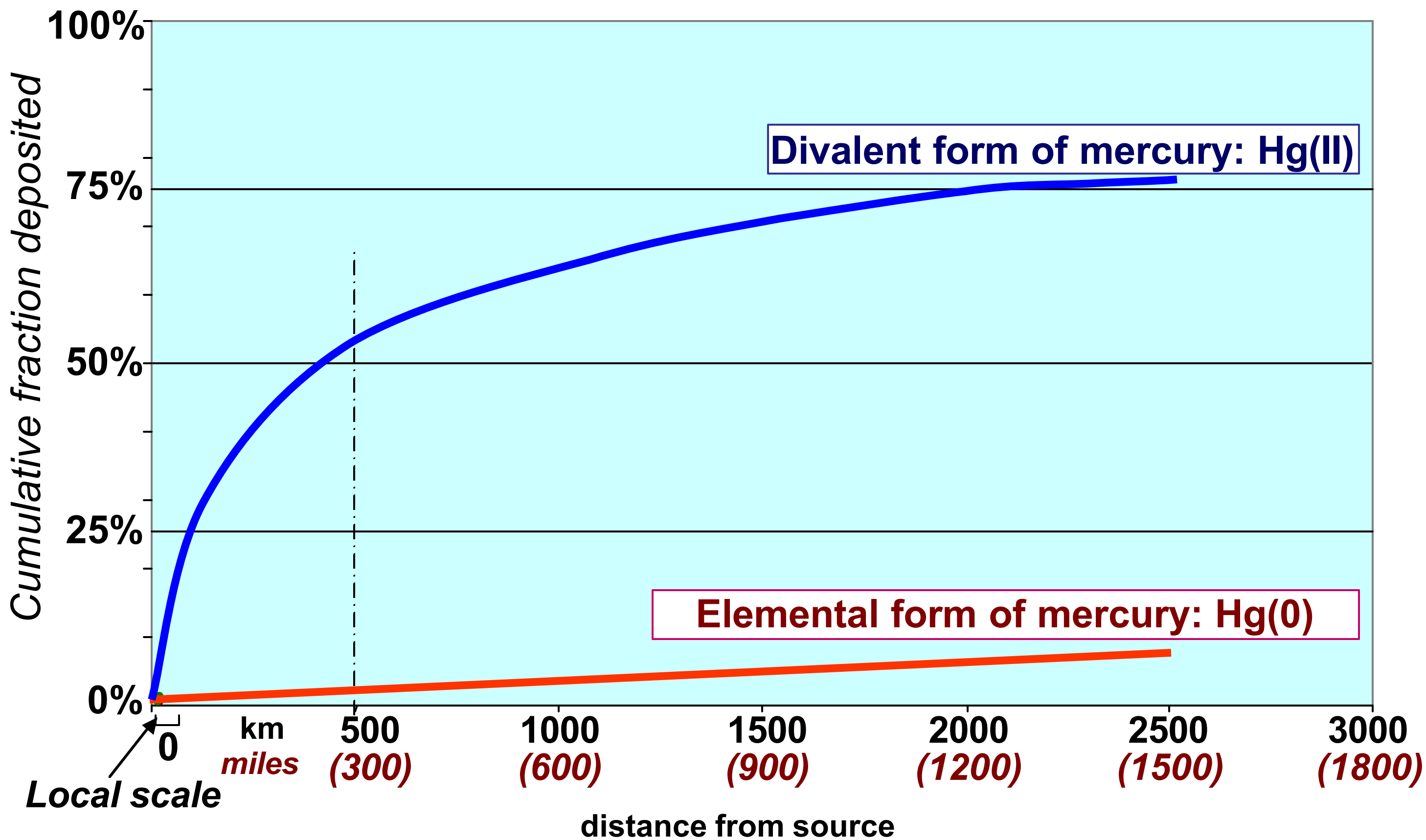
- **Scenarios, not projections [*Meaning:* emissions from other U.S. and global sources are kept constant; but these may increase in time, so deposition drops due to just utility controls may be less]**
- **Incomplete knowledge [*Meaning:* chemistry, physics not fully understood → overall adjustments ± in final picture]**
- **Static picture [*Meaning*: no time progression is considered; actual adjustments may be delayed from time of emissions changes]**

UTILITY EMISSIONS OVER TIME: Economic model results



ELECTRIC POWER RESEARCH INSTITUTE

Two primary forms of mercury (elemental and divalent or RGM); both travel 100s of miles before depositing



Courtesy Mark Cohen, NOAA

TIME GAPS IN MERCURY COMPARTMENTS

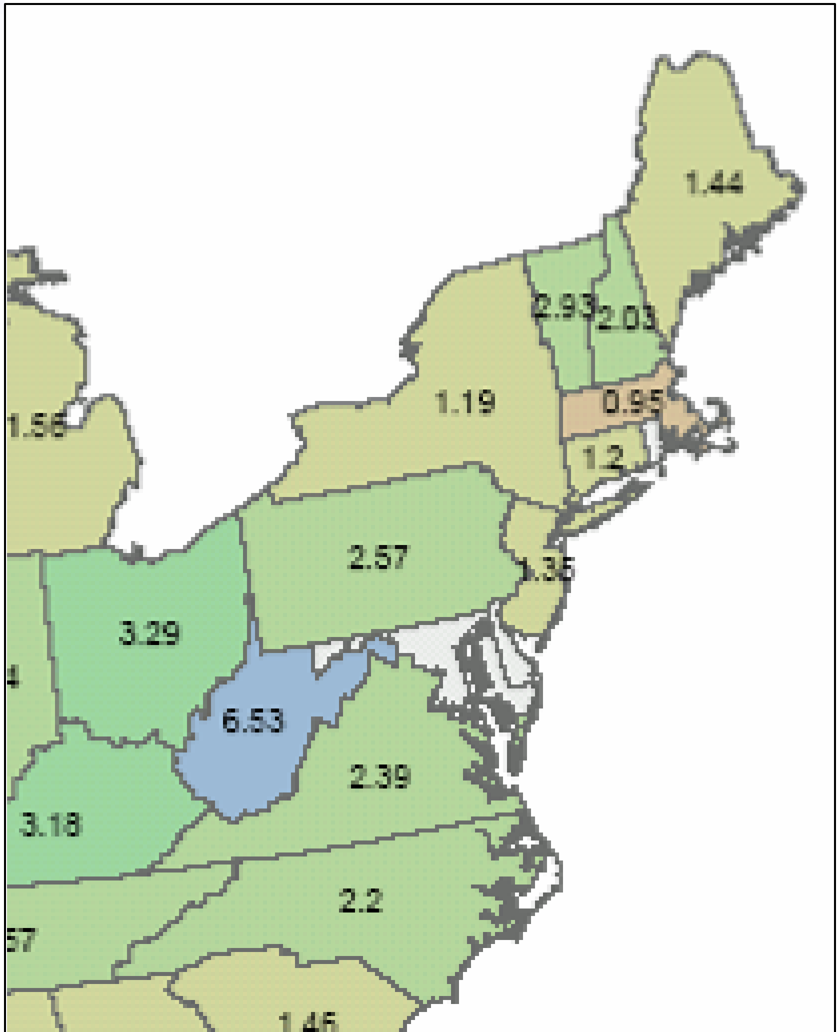
FROM	TO	TIME SCALE	PROCESS
(instantaneous) DROP IN EMISSIONS	DROP IN DEPOSITION (local-regional scale)	Days [From mercury spp. lifetimes in atmosphere]	Lowering of local+regional (divalent) plus regional+global (elemental) transport
DROP IN DEPOSITION	INITIAL MEASUREABLE DECLINE IN WATERBODY MERCURY	Months [Data: Mass., Florida]	Adjustment of watershed, bottom sediment mercury retardation and “buffering”
INITIAL DECLINE IN WATERBODY MERCURY	FULL DECLINE IN WATERBODY MERCURY	Months to Years [Data: METAALICUS]	Retardation by watershed, multiyear filtering
DROP IN DEPOSITION	FULL DECLINE IN FISH MERCURY	Years to Decades [Data: METAALICUS]	Watershed retardation, fish maturation reservoir

U.S. Mercury Exposure: Data Through 2004

- Data: national health survey of women by Centers for Disease Control; blood samples plus fish consumption recall survey
- Continued drop in exposure, U.S. women of childbearing age
- Fish consumption surveys showed increase in this period

Federal NHANES Survey, Blood Mercury Concentration Women Aged 16–49			
SURVEY BIENNIUM	Number of Samples	Mean, Total Hg, µg/L	National percent of women with blood mercury above EPA health threshold
1999–2000	*1709*	*2.00*	*7.1%*
2001–2002	*1928*	*1.45*	*3.4%*
2003–2004	*1824*	*1.35*	*1.9%*
1999–2004	*5461*	*1.58*	*3.96%*

Drop in Mercury Exposure, by State, 2020



Percentage decrease in blood mercury levels of most-exposed women of childbearing age, by state, based on NHANES data through 2004.

Limiting factors:

- **U.S. mercury fraction with non-U.S. origin**
- **80+% of U.S. fish consumed = marine origin**
- **75% of marine fish in U.S. commerce is from North Pacific (upwind of U.S. sources)**
- **Most changes by U.S. will impact U.S. freshwater fish (closer to changing emissions): but those are less than 10% of fish consumed**
- **Largest deposition drops do not occur over fished waters**

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

CONCLUSIONS

1. Most mercury remaining after CAMR is ELEMENTAL
2. Elemental mercury takes 100s to 1,000s of miles to significantly deposit (→oxidation, wet+dry deposition)
3. Elemental mercury emissions play lesser role in in-state (= local) deposition
4. Drops in deposition are limited by contributions from other sources
5. Changes in fish levels of mercury may be evident within several years, but fully realized after many years to decades
6. There may be surprises* in the system (*good or bad): incomplete understanding of the science